



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> :  C07K 5/00		A2	(11) International Publication Number: <b>WO 99/32509</b>  (43) International Publication Date: 1 July 1999 (01.07.99)
<p>(21) International Application Number: PCT/CA98/01184</p> <p>(22) International Filing Date: 18 December 1998 (18.12.98)</p> <p>(30) Priority Data: 2,225,325 19 December 1997 (19.12.97) CA</p> <p>(71) Applicant (<i>for all designated States except US</i>): THE UNIVERSITY OF BRITISH COLUMBIA [CA/CA]; IRC Room 331, 2194 Health Sciences Mall, Vancouver, British Columbia V6T 1Z3 (CA).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (<i>for US only</i>): ANDERSEN, Raymond [CA/CA]; 4048 West 32nd Avenue, Vancouver, British Columbia V6S 1Z6 (CA). PIERS, Edward [CA/CA]; (CA). NIEMAN, James [CA/CA]; (CA). COLEMAN, John [CA/CA]; The University of British Columbia, Dept. of Chemistry, 6328 Memorial Road, Vancouver, British Columbia V6T 1Z3 (CA). ROBERGE, Michel [CA/CA]; 4228 West 10th Avenue, Vancouver, British Columbia V6R 2H4 (CA).</p> <p>(74) Agents: ROBINSON, J., Christopher et al.; Smart &amp; Biggar, Suite 2200, 650 West Georgia Street, Box 11560, Vancouver, British Columbia V6N 4N8 (CA).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i></p>	
<p>(54) Title: HEMIASTERLIN ANALOGS</p> <p>(57) Abstract</p> <p>This invention provides analogs of hemiasterlin, methods of synthesis of the analogs and use of the analogs as a cytotoxic and anti-mitotic agents.</p>			

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

HEMIASTERLIN ANALOGSField of Invention

5 This invention relates to biologically active compounds and compositions, their use and derivation.

Background

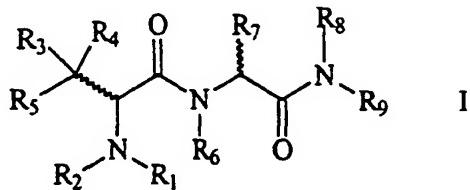
10 As described in Talpir, R. *et al.* (1994) Tetrahedron Lett. 35:4453-6 and in international patent application PCT/GB96/00942 published October 24, 1996 under number WO96/33211, the compound hemiasterlin may be obtained from marine sponges or synthesized. As set forth 15 in PCT/GB96/00942, hemiasterlin and the synthetic analogs described therein are cytotoxic and anti-mitotic.

20 Compounds that differ from hemiasterlin in the region of the indole moiety of hemiasterlin are novel. It has now been found that analogs of hemiasterlin wherein the indole moiety of hemiasterlin has been deleted or replaced demonstrate potent anti-mitotic and cytotoxic activity.

Summary of Invention

25 This invention provides a compound or pharmaceutically acceptable salt thereof, having the formula

30



35

wherein,

- 2 -

R<sub>1</sub> and R<sub>2</sub> are independently selected from the group consisting of: H, R, and ArR-, and where at least one of R<sub>1</sub> and R<sub>2</sub> is R and neither are ArR-, R<sub>1</sub> and R<sub>2</sub> together may optionally be a three to seven membered ring;

5

R<sub>3</sub> and R<sub>4</sub> are independently selected from the group consisting of: H, R, ArR-, and where at least one of R<sub>3</sub> and R<sub>4</sub> is R and neither are ArR- or Ar, R<sub>3</sub> and R<sub>4</sub> together may optionally be a three to seven membered ring;

10

R<sub>5</sub> is selected from the group consisting of: H, R, ArR-, and Ar;

15 R<sub>6</sub> is selected from the group consisting of: H, R, and ArR-;

R<sub>7</sub> and R<sub>8</sub> are independently selected from the group consisting of: H, R, and ArR-; and

20

R<sub>9</sub> is: Z-C<sup>Q</sup>-Y-;

and wherein,

25 R is defined as a saturated or unsaturated moiety having a linear, branched, or cyclic skeleton containing one to ten carbon atoms, zero to four nitrogen atoms, zero to four oxygen atoms, and zero to four sulfur atoms, and the carbon atoms are optionally substituted with: =O, =S, OH, -OR<sub>10</sub>, -O<sub>2</sub>CR<sub>10</sub>, -SH, -SR<sub>10</sub>, -SO<sub>2</sub>CR<sub>10</sub>, -NH<sub>2</sub>, -NHR<sub>10</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -NHCOR<sub>10</sub>, -NR<sub>10</sub>COR<sub>10</sub>, -I, Br, -Cl, -F, -CN, -CO<sub>2</sub>H, -CO<sub>2</sub>R<sub>10</sub>, -CHO, -COR<sub>10</sub>, -CONH<sub>2</sub>, -CONHR<sub>10</sub>, -CON(R<sub>10</sub>)<sub>2</sub>, -COSH, -COSR<sub>10</sub>, -NO<sub>2</sub>, -SO<sub>3</sub>H, -SOR<sub>10</sub>, -SO<sub>2</sub>R<sub>10</sub>, wherein R<sub>10</sub> is a linear, branched or cyclic, one to ten carbon saturated or unsaturated alkyl group;

35

X is defined as a moiety selected from the group consisting of: -OH, -OR, =O, =S, -O<sub>2</sub>CR, -SH, -SR, -SO<sub>2</sub>CR,

- 3 -

-NH<sub>2</sub>, -NHR, -N(R)<sub>2</sub>, -NHCOR, -NRCOR, -I, -Br, -Cl, -F, -CN, -CO<sub>2</sub>H, -CO<sub>2</sub>R, -CHO, -COR, -CONH<sub>2</sub>, -CONHR, -CON(R)<sub>2</sub>, -COSH, -COSR, -NO<sub>2</sub>, -SO<sub>3</sub>H, -SOR, and -SO<sub>2</sub>R;

5 Ar is defined as an aromatic ring selected from the group consisting of: phenyl, naphthyl, anthracyl, phenanthryl, furyl, pyrrolyl, thiophenyl, benzofuryl, benzothiophenyl, quinolyl, isoquinolyl, imidazolyl, thiazolyl, oxazolyl, and pyridyl, optionally substituted  
10 with R or X;

Y is defined as a moiety selected from the group consisting of: a linear, saturated or unsaturated, one to six carbon alkyl group, optionally substituted with R,  
15 ArR-, or X; and,

Z is defined as a moiety selected from the group consisting of: -OH, -OR; -SH; -SR; -NH<sub>2</sub>; -NHR; -N(R)<sub>2</sub>; -NHCH(R<sub>11</sub>)COOH; and -NRCH(R<sub>11</sub>)COOH, wherein R<sub>11</sub> is a moiety  
20 having the formula: R, or -(CH<sub>2</sub>)<sub>n</sub>NR<sub>12</sub>R<sub>13</sub>, wherein n=1-4 and R<sub>12</sub> and R<sub>13</sub> are independently selected from the group consisting of: H; R; and -C(NH)(NH<sub>2</sub>).

This invention also provides methods of preparing the  
25 aforementioned compound of formula I, and precursors thereof, as described herein.

This invention also provides the use of the  
aforementioned compound of formula I, or a pharmaceutically  
30 acceptable salt thereof, for:

- (a) manufacture of a medicament;
- (b) in a method whereby cells, including tumor cells, which are susceptible to the cytotoxic effects of the compound are treated with the compound or a pharmaceutically acceptable salt thereof; and

- 4 -

- (c) in a method whereby cells are treated with the compound or a pharmaceutically acceptable salt thereof, to bring about mitotic arrest in the cells, or the production of abnormal mitotic spindles in the cells.

Description of Figures

Figure 1 is a schematic showing a preferred scheme for synthesis of a compound of this invention.

Figure 2 is a schematic showing a preferred scheme for synthesis of the amino acid used in the coupling reaction shown in Figure 1.

Figure 3 is a schematic showing steps in the synthesis of a compound of this invention as described in the examples herein.

Figure 4 is a schematic showing steps in the synthesis of the dipeptide shown in Figure 3, as described in the examples herein.

Figure 5A and 5B are graphs comparing the cytotoxicity of hemiasterlin to SPA-110, as described in the examples herein.

Figure 6 is a graph comparing the anti-mitotic activity of SPA-110 (♦) to hemiasterlin (□), as described in the examples herein.

- 5 -

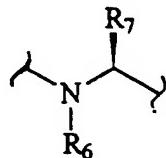
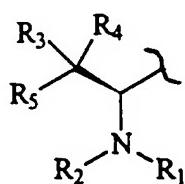
Detailed Description of the Invention

Except where otherwise stated, the recitation of a compound herein covers all possible salts of the compound, and denotes all possible isomers possible within the structural formula given for such compound, including geometrical and optical isomers. Unless otherwise stated, materials described herein comprising a compound for which isomers exist, are to be regarded as covering individual isomers, and, mixtures of isomers including racemic mixtures.

In the compound of formula I set out above, bonds drawn in wavy line are from carbon atoms which may be optical centers. Preferably, the following absolute configurations predominate:

20

25



30

Except where otherwise stated, any moiety referred to herein which is described as "alkyl" will preferably be straight chain or, branched when possible, and will preferably have up to eight, more preferably up to six and even more preferably up to four carbon atoms. Except where otherwise stated optionally substituted alkyl groups are

- 6 -

preferably unsubstituted. Methyl is the most preferred alkyl group.

In this specification, reference is made to alkyl 5 moieties being saturated or unsaturated, thereby including within the definition of the moiety, alkene and alkyne groups (whether internal, terminal or part of a ring).

In a compound of formula I, the following substituents 10 alone, or in combination, are preferred:

- (a) R<sub>1</sub> and R<sub>2</sub> independently: H, methyl, ethyl, propyl, n-butyl, acetyl; or, where R<sub>1</sub> and R<sub>2</sub> are joined: cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl; more preferably R<sub>1</sub> and R<sub>2</sub> are independently: H or CH<sub>3</sub>; most preferably R<sub>1</sub> is H and R<sub>2</sub> is CH<sub>3</sub>;
- (b) preferably no more than one of R<sub>3</sub> and R<sub>4</sub> is H; 20 more preferably, R<sub>3</sub> and R<sub>4</sub> are independently: methyl, ethyl, n-propyl or n-butyl, or, where R<sub>3</sub> and R<sub>4</sub> are joined:  $\beta$ -cyclopropyl,  $\beta$ -cyclobutyl,  $\beta$ -cyclopentyl or  $\beta$ -cyclohexyl; most preferably R<sub>3</sub> and R<sub>4</sub> are each methyl;
- (c) R<sub>5</sub>: Ar in the definition of R<sub>5</sub> is preferably phenyl, naphthyl, anthracyl or pyrrolyl; preferably R<sub>5</sub> is phenyl, methyl or H; most preferably R<sup>5</sup> is phenyl or methyl;
- (d) R<sub>6</sub> and R<sub>8</sub> independently: H or methyl, more preferably R<sub>6</sub> is H and R<sub>8</sub> is methyl;
- (e) R<sub>7</sub>: a three to six carbon, branched alkyl group; 35 more preferably R<sub>7</sub> is -C(CH<sub>3</sub>)<sub>3</sub>; and

- 7 -

(f) in R<sub>9</sub>, Z is preferably OH, -OR<sub>14</sub> (wherein R<sub>14</sub> is a linear or branched one to six carbon alkyl group, -NHCH(R)<sub>11</sub>)COOH or -NCH<sub>3</sub>CH(R<sub>11</sub>)COOH wherein R<sub>11</sub> is R, or -(CH<sub>2</sub>)<sub>n</sub>NHC(NH)(NH<sub>2</sub>); or R<sub>9</sub> is preferably

5

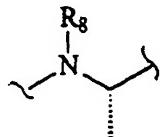
-C-C=C(R<sub>16</sub>)C-OH wherein R<sub>15</sub> is methyl, ethyl,  
R<sub>15</sub>

10 n-propyl, isopropyl, tert-butyl, iso-butyl, or sec-butyl and R<sub>16</sub> is H, methyl, ethyl, propyl, iso-propyl, n-butyl, iso-butyl or sec-butyl; more preferably Z is OH and R<sub>9</sub> as a whole is:

15 -C-C=C(CH<sub>3</sub>)COH  
CH(CH<sub>3</sub>)<sub>2</sub>

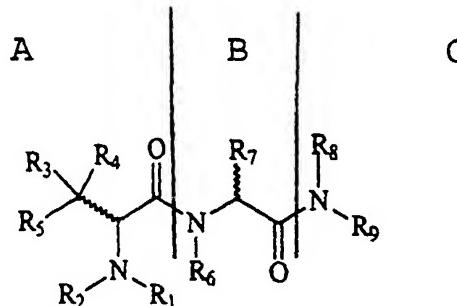
Where R<sub>9</sub> has a chiral center in moiety Y, the following absolute configuration is preferred, with reference to an example where the chiral center has a methyl substituent:

25



Compounds of formula I may be prepared by coupling 30 moieties A, B and C as represented below using standard procedures, including procedures for coupling amino acids through a peptide bond.

35



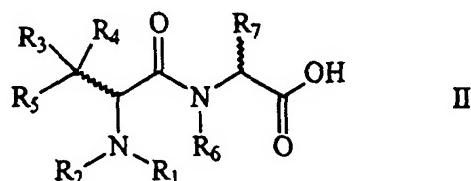
- 8 -

A coupling agent, for example PyBroP, is suitably used in the reaction. The reaction suitably comprises connecting amino acid moieties in the presence of the 5 coupling agent, a base such as 4-dimethylaminopyridine and an organic solvent such as methylene chloride. Standard reaction quenching and purification procedures known in the art produce the coupled compound.

10 Preparation of moieties B and C as described above may be carried out using procedures and starting materials known in the art, for example by following the methods described in the aforementioned PCT/GB96/00942. The methods as set out in the examples herein may be employed, 15 with suitable modification to materials and reagents, according to particular substituents of moieties A, B and C.

One aspect of this invention is a method for preparing 20 a compound of formula I in which a compound of the formula:

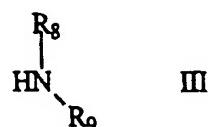
25



30

is coupled with a compound of the formula:

35



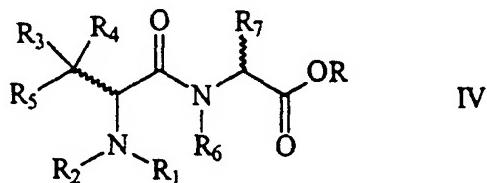
- 9 -

A compound of formula III may be prepared by known methods (such as described in PCT/GB96/00942) and by the  
5 method described in the examples herein.

A further aspect of this invention is a method for preparing a compound of the formula II described above in which a compound of the formula:

10

15



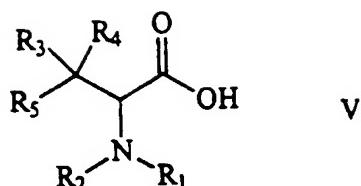
20

is treated with a base such as dilute sodium hydroxide in a solvent such as methanol for enough time to allow removal of OR; followed by acidification to about pH 3. Preferably R in formula IV is a simple alkyl chain, such as CH<sub>3</sub>, and a protecting agent such as tert-butoxycarbonyl (Boc) may be used to protect the amine group; i.e. R<sub>1</sub> or R<sub>2</sub> is replaced by Boc. The Boc group is suitably removed by a reaction such as TFA/CH<sub>2</sub>Cl<sub>2</sub> for about 1 hour at ambient temperatures. An appropriate isolation protocol produces the TFA salt.  
25 Subsequently another group (eg. R<sub>1</sub> or R<sub>2</sub>) could be introduced on the nitrogen by standard techniques known to any person in the art, which produces compound of formula IV.  
30

35 A further aspect of this invention is a method for preparing a compound of formula IV described above in which a compound of the formula:

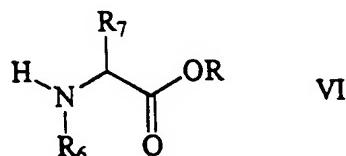
- 10 -

5



10

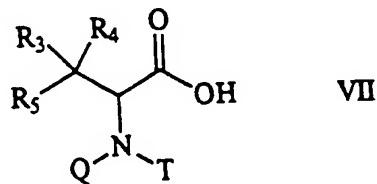
15



Preparation of compound V can be accomplished by many procedures known to person skilled in the art. One such example is described below in Figure 2. Compounds of formula VI may be prepared by methods known to persons of skill in the art.

A preferred method according to this invention for preparing a compound of formula I, is to prepare a dipeptide comprising moieties B and C and couple the dipeptide to moiety A. In this method, a compound of the following formula, wherein Q and T together are a combination of any two of the substituents: R<sub>1</sub>, R<sub>2</sub> and a protecting group:

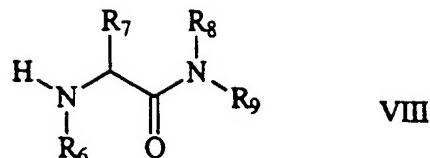
35



is coupled with a compound of the formula:

- 11 -

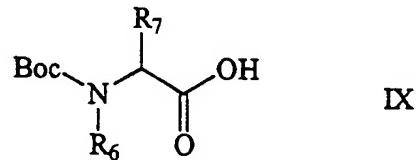
5



10

A compound of formula VIII may be prepared by coupling a compound of formula III as described above, with a compound of the formula:

15



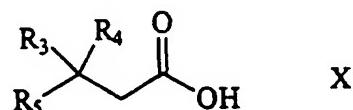
20

Compounds of formula IX may be prepared by methods known to persons of skill in the art.

25

A further aspect of this invention is a method to prepare a compound of formula VII as described above in which a compound of the formula:

30



35

- 12 -

is treated with a base followed by an azide compound. The azide derivative so produced is reduced to form an amine which is then treated with groups selected from: R<sub>1</sub>, R<sub>1</sub> and Boc in the presence of a base such as sodium hydride.

5

Figure 1 sets out a preferred scheme for preparation of a compound of formula I involving the coupling of amino acid moiety A with a dipeptide comprising moieties B and C. In the embodiment shown in the figure, the substituents of 10 the dipeptide are those of hemiasterlin. The Boc protected dipeptide portrayed in the figure may be obtained by the methods set out in the examples herein. On the A moiety, Boc may replace R<sub>1</sub> rather than R<sub>2</sub> or both R<sub>1</sub> and R<sub>2</sub> may be present on the A moiety prior to coupling.

15

Figure 2 sets out a preferred scheme for preparation of moiety A as used in the scheme shown in Figure 1. R<sub>2</sub> may be added in place of Boc and Boc may replace R<sub>1</sub>.

20

Compounds of formula I are biologically active. The invention includes the use of a compound of formula I. Compounds of formula I may have pesticidal, for example insecticidal activity. Preferably, however, the use is in the pharmaceutical field for medical or veterinarial 25 applications.

The compounds described herein have utility as cytotoxic agents, particularly against tumor cells and may have utility as anti-bacterial or anti-viral agents. 30 Therefore, this invention includes a pharmaceutical composition comprising an effective amount of a compound of formula I, in association with a carrier.

This invention further provides the use of a compound 35 of formula I for the manufacture of a medicament for use in the treatment of cancer or a tumor in a mammal.

- 13 -

In using a compound of formula I for medical or veterinarial applications, the compound is preferably administered in a pharmaceutical composition comprising also a pharmaceutically acceptable carrier, and optionally, 5 one or more other biologically active ingredients. Such compositions may be in any form used for administering pharmaceuticals, for example any form suitable for oral, topical, vaginal, intravenous, subcutaneous, parenteral, rectal and inhalatory application. The compositions may be provided in discrete dose units. The carriers may be 10 particulate, with the compositions being, for example, tablets or powders, or liquid, with the compositions being, for example, oral syrups or injectable liquids, or aerosol, for inhalatory application.

15

For oral administration an excipient and/or binder may be present. Examples are sucrose, kaolin, glycerin, starch dextrins, sodium alginate, carbosymethylcellulose and ethyl cellulose. Colouring and/or flavouring agents may be 20 present. A coating shell may be employed. For rectal administration oleaginous bases may be employed, for example lanolin or cocoa butter. For an injectable formulation buffers, stabilizers and isotonic agents may be included.

25

The dosage of a compound of formula I may depend upon the weight and physical condition of the patient; on the severity and longevity of the illness; and on the particular form of the active ingredient, the manner of 30 administration and the composition employed. A daily dose of about 0.0001 to about 100 mg/kg of body weight taken singly or in separate doses of up to 6 times a day, or by a continuous infusion, embraces the effective amounts most typically required. A preferred range is about 0.001 to 35 about 50 mg/kg of body weight, per day, most preferably about 0.01 to about 30 mg/kg of body weight, per day.

- 14 -

It is to be understood that use of a compound of formula I in chemotherapy can involve such a compound being bound to an agent, for example a monoclonal or polyclonal antibody, a protein or a liposome, which assists the 5 delivery of the said compound to tumor cells.

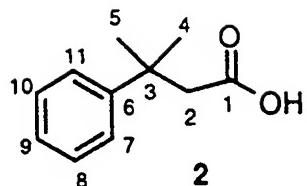
This invention also includes the use of a compound of formula I as an antimitotic agent. Such use may be in procedures that require blocking cells in mitosis, such as 10 the preparation of mitotic spreads for karyotype analysis. The compounds of this invention can also be used to probe microtubule function in mitotic cells.

Examples

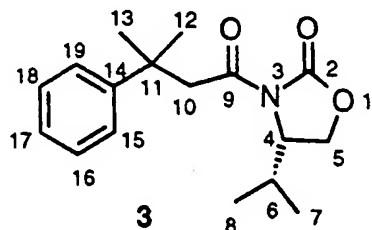
15

The following examples provide a detailed description of preferred methods of synthesis of a preferred compound of this invention, SPA-110. Also described are precursor compounds and characterization of various compounds of this 20 invention. Figures 3 and 4 schematically portray the synthesis of the a SPA-110 salt according to the examples. Reference numerals in the examples correspond to labelling of compounds in Figures 3 and 4 and labelling of compounds depicted in the examples.

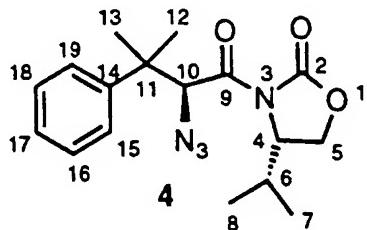
25

3-methyl-3-phenylbutanoic acid (2)

3-Methyl-2-butenoic acid (**1**, 5.10 g, 50.9 mmol) and AlCl<sub>3</sub> (20.4 g, 153 mmol) were placed in a one-neck round-bottomed flask. Benzene (50 mL) was added, which produced vigorous bubbling. Upon completion of the bubbling, a capped condenser (*i.e.* closed system) was attached, the reaction mixture was stirred and placed in an oil bath at 65°C. The pressure in the system was occasionally released. The progress of the reaction was followed by following the loss of starting material by GC. If the reation was not complete within 1 h, a small quantity of AlCl<sub>3</sub> was added and stirring was continued. To the solution was added diethyl ether and the mixture was cooled to 0°C. Slowly conc. HCl and some water were added until all the solid dissolved and the pH was less than 2. The aqueous layer was extracted with diethyl ether three times. The organic layer was concentrated to 150 mL and then was extracted with a saturated sodium hydrogen carbonate solution six times. The combined aqueous layer were acidified with conc. HCl until the pH was less than 2. The acidic aqueous layer was extracted with diethyl ether three times and the accumulated organic layer was dried with magnesium sulfate. The solution was filtered and the diethyl ether was removed *in vacuo* producing a white solid (8.51 g, 47.7 mmol) in 94% yield, which did not need further purification. mp 55 - 56°C. <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) 10.45 (bs, 1H, CO<sub>2</sub>H), 7.38 (d, 2H, J = 7.2 Hz, H-11 and H-7), 7.32 (t, 2H, J = 7.2 Hz, H-10 and H-8), 7.21 (t, 2H, J = 7.2 Hz, H-9), 2.65 (s, 2H, H-2), 1.47 (s, 6H, H-5 and H-4); Mass spectrum (EI) 178 (23, M<sup>+</sup>), 119 (100, [C<sub>9</sub>H<sub>11</sub>]<sup>+</sup>). For pioneering work to form **2** see: F.J. Eijkman (1908) Chem. Kentr. II, p. 110; or A. Hoffman (1929) J. Am. Chem. Soc. 51:2542.

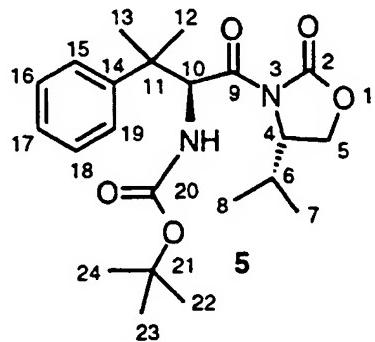
(4S)-3-(3-methyl-3-phenyl-1-oxobutyl)-4-isopropyl-2-oxazolidinone (3)

3-Methyl-3-phenylbutanoic acid (**2**, 1.00 g, 5.61 mmol) was dissolved in 70 mL of THF and cooled to -78°C. Triethylamine (1.17 mL, 8.42 mmol) and trimethylacetyl chloride (0.760 mL, 6.17 mmol) were added to the reaction flask producing a white solid. The resulting mixture was warmed to 0°C for 1 h and then cooled back down to -78°C. In a second flask butyllithium (6.84 mL, 1.6 M in hexanes, 10.9 mmol) was added dropwise with vigorous stirring to a solution of (4S)-(-)-4-isopropyl-2-oxazolidinone (1.45 g, 11.2 mmol) at -78°C in THF (60 mL) producing a white precipitate. The resulting suspension of the lithiated oxazolidinone was added *via* cannula to the reaction flask. Stirring was continued for 2 h, water was added and the reaction mixture was warmed to room temperature, whereupon it was extracted three times with diethyl ether. The combined organic extracts were dried over magnesium sulfate, and concentrated *in vacuo*. The product was purified by radial chromatography (4 mm plate, 3 : 7 diethyl ether - pet. ether) affording compound **3** as a clear, colourless oil in 84% yield (1.37 g, 4.74 mmol). <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) 7.38 (d, 2H, J = 7.3 Hz, H-19 and H-15) 7.28 (t, 2H, J = 7.3 Hz, H-18 and H-16), 7.16 (t, 1H, J = 7.3 Hz, H-17), 4.22 - 4.18 (m, 1H, H-4), 4.05 (dd, 1H, J = 9.0 and 2.8 Hz, 1H-5), 4.00 (t, 1H, J = 9.0 Hz, 1H-5), 3.38 - 3.30 (m, 2H, H-10), 2.16 - 2.12 (m, 1H, H-6), 1.48 (s, 3H, H-13 or H-12), 1.47 (s, 3H, H-13 or H-12), 0.79 (d, 3H, J = 7.1 Hz, H-8 or H-7), 0.71 (d, 3H, J = 6.9 Hz, H-8 or H-7); Mass spectrum (EI) 289 (8, M<sup>+</sup>), 119 (100, [C<sub>9</sub>H<sub>11</sub>]<sup>+</sup>). Optical rotation obtained was  $[\alpha]_D^{25} +69.5$  (c 1.16, CHCl<sub>3</sub>). Compound **3** was prepared according to D.A. Evans *et al.* (1988) Tetrahedron 44:5525.

Preparation of the 4-isopropyl-2-oxazolidinone 4

Oxazolidinone **3** (472 mg, 1.63 mmol), dried under high vacuum for 0.5 h, was dissolved in THF and cooled to -78°C (10 mL). Freshly titrated potassium bis(trimethylsilyl)amide (15.6 mL, 0.115 M in THF, 1.79 mmol) was added and the resulting solution was stirred at -78°C for 1 h. A solution of 2,4,6-triisopropylbenzenesulfonyl azide (625 mg, 2.04 mmol) in THF (5 mL) at -78°C was added *via cannula* and after 2 min. the orange coloured reaction mixture was treated with glacial acetic acid (0.429 mL, 7.50 mmol), warmed to 40°C in a water bath and stirred for a further hour. To the light yellow mixture was added brine (35 mL), water (35 mL) and the aqueous phase was extracted three times with 80 mL diethyl ether. The combined organic extracts were washed with a saturated sodium hydrogen carbonate solution (20 mL), dried with magnesium sulfate and concentrated *in vacuo*. The product was purified by radial chromatography (4 mm plate, 3 : 7 diethyl ether - pet. ether, sample was loaded with diethyl ether) affording azide **5** as a colourless oil (482 mg, 1.46 mmol) in 89% yield. <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) 7.39 (d, 2H, J = 7.2 Hz, H-19 and H-15), 7.31 (t, 2H, J = 7.2 Hz, H-18 and H-16), 7.23 (t, 1H, J = 7.2 Hz, H-17), 5.64 (s, 1H, H-10), 3.95 (dd, 1H, J = 8.7 and 2.2 Hz, 1H-5), 3.89 - 3.85 (m, 1H, H-4), 3.56 (t, 1H, J = 8.7 Hz, 1H-5), 2.31 - 2.26 (m, 1H, H-6), 1.54, 1.52 (s, 3H, H-13 and H-12), 0.83 (d, 3H, J = 7.0 Hz, H-8 or H-7), 0.79 (d, 3H, J = 6.9 Hz, H-8 or H-7); Mass spectrum (DCI, NH<sub>3</sub>) 349 (45, [M+NH<sub>5</sub>]<sup>+</sup>), 348 (100, [M+NH<sub>4</sub>]<sup>+</sup>), 331 (12, [M+H]<sup>+</sup>), 303 (57, [M-N<sub>2</sub>]<sup>+</sup>), 119 (94, [C<sub>9</sub>H<sub>11</sub>]<sup>+</sup>). Optical rotation obtained was  $[\alpha]_D^{25} +121.5$  (c 1.1, CHCl<sub>3</sub>). Compound **4** was prepared according to the methodology developed by D.A. Evans *et al.* (1990) J. Am. Chem. Soc. 112: 4011. 2,4,6-Triisopropylbenzenesulfonyl azide was prepared by the method of O.C. Dermer *et al.* (1955) J. Am. Chem. Soc. 77:70.

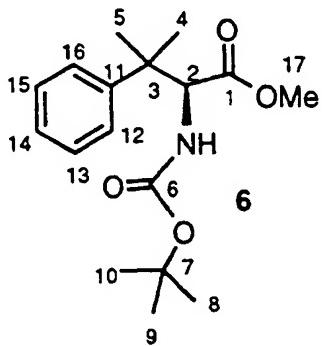
#### Preparation of the 4-isopropyl-2-oxazolidinone **5**



Azide **4** (418 mg, 1.26 mmol), 10% palladium on charcoal (280 mg), and di-*tert*-butyl dicarbonate (608 mg, 2.78 mmol) were placed in a 100 mL flask. Ethyl acetate (37 mL) was added and the resulting black suspension was stirred at room temperature. The mixture was

flushed with argon, then with hydrogen and was stirred under a hydrogen balloon overnight (~14 h). The reaction mixture was filtered through silica gel and the collected material was washed with ethyl acetate. The combined filtrate was concentrated *in vacuo* and the crude mixture was purified by flash column chromatography (3 : 7 diethyl ether - pet. ether) to afford compound 5, a viscous colourless oil, in 78% yield (400 mg, 0.989 mmol). <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) 7.40 (d, 2H, *J* = 7.4 Hz, H-19 and H-15), 7.29 (t, 2H, *J* = 7.4 Hz, H-18 and H-16), 7.21 (t, 1H, *J* = 7.4 Hz, H-17), 6.12 (d, 1H, *J* = 9.9 Hz, H-10), 5.11 (bs, 1H, N-H), 3.89 (d, 1H, *J* = 8.4 and 1.9 Hz, H-5), 3.82 - 3.79 (m, 1H, H-4), 3.45 (t, 1H, *J* = 8.4 Hz, H-5), 2.26 - 2.22 (m, 1H, H-6), 1.41 (s, 9H, H-24, H-23 and H-22), 0.80 (d, 3H, *J* = 7.0 Hz, H-8 or H-7), 0.76 (d, 3H, *J* = 6.9 Hz, H-8 or H-7); Mass spectrum (DCI, CH<sub>4</sub>/NH<sub>3</sub> mix) 405 (1, [M+H]<sup>+</sup>), 349 (7, [M-C<sub>4</sub>H<sub>9</sub>]<sup>+</sup>), 230 (100, [C<sub>9</sub>H<sub>14</sub>N<sub>2</sub>O<sub>5</sub>]<sup>+</sup>). Optical rotation obtained was  $[\alpha]_D^{24}$  +118.4 (c 0.935, CHCl<sub>3</sub>). Compound 5 was prepared according to the methodology developed by D.A. Evans *et al.* (1990) [supra].

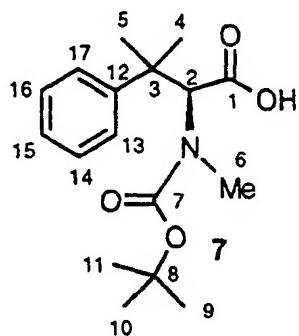
Methyl (2S)-2-(*tert*-butyloxycarbonyl)amino-3-methyl-3-phenylbutanoate (6)



Oxazolidinone 5 (245 mg, 0.605 mmol) was dissolved in a mixture of 7.1 mL THF and 1.8 mL water. This solution was cooled to 0°C and hydrogen peroxide (0.618 mL, 30% aqueous, 5.45 mmol) and lithium hydroxide (1.82 mL, 1.0 M, 1.82 mmol) were added. The resulting mixture was stirred at room temperature overnight (~15 h). The excess peroxide was quenched by addition of sodium hydrogen sulfite (7.1 mL, 1.5 M, 10.7 mmol) and stirring was continued for 1 h. The aqueous phase was acidified with 1.0 M citric acid and the mixture was extracted three times with ethyl acetate. The combined ethyl acetate extracts were dried over magnesium sulfate and concentrated *in vacuo*. To the remaining crude material was added a solution of diazomethane in diethyl ether until the solution stayed yellow. After bubbling argon through the solution for 15 min., the remaining volatile components were removed *in vacuo* to afford crude compound 6. Purification of ester 6 was accomplished by radial chromatography (2 mm plate, 3 : 7 diethyl ether - pet. ether, sample was loaded with CHCl<sub>3</sub>), producing a clear colourless oil (171 mg, 0.555) in

92% yield.  $^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) 7.33 - 7.27 (m, 4H, H-16, H-15, H-13, H-12), 7.20 (t, 1H,  $J = 6.7$  Hz, H-14), 4.99 (bd, 1H,  $J = 8.8$  Hz, H-2), 4.50 (bd, 1H,  $J = 8.8$  Hz, N-H), 3.48 (s, 3H, H-17), 1.41, 1.38 (s, 3H, H-5 and H-4), 1.37 (s, 9H, H-10,H-9, and H-8); Mass spectrum (EI) 307 (0.1,  $M^+$ ), 234 (2,  $[\text{M}-\text{Or-Bu}]^+$ ), 119 (100,  $[\text{C}_9\text{H}_{11}]^+$ ). Optical rotation obtained was  $[\alpha]_D^{25} +35.2$  (c 2.98,  $\text{CHCl}_3$ ). Compound 5 was prepared according to the methodology developed by D.A. Evans *et al.* (1990) [supra].

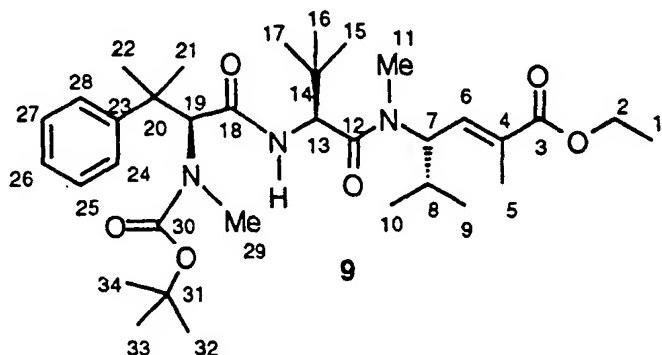
(2S)-N-tert-butoxycarbonyl-N-methyl-3-methyl-3-phenylbutanoic acid (7)



To a vigorously stirred solution of ester 6 (43.4 mg, 0.141 mmol) in 2 mL dry DMF were added sodium hydride (10.2 mg, 4.24 mmol) followed by methyl iodide (0.088 mL, 1.41 mmol) and the resulting grey suspension was stirred overnight (~20 h) at room temperature. The excess sodium hydride was quenched by cautious addition of water and the mixture was acidified by dropwise addition of 1.0 M citric acid. The acidic mixture was extracted three times with ethyl acetate, the combined organic layer extracted three times with brine, dried over magnesium sulfate and concentrated *in vacuo*. The resulting light orange oil was dissolved in 4 mL methanol in a 25 mL flask. To the solution was added 1.0 mL of water, followed by 1.13 mL of 1.0 M lithium hydroxide. The reaction mixture was heated at 60°C overnight (~14 h), producing a white precipitate. To the resultant mixture was added saturated sodium hydrogen carbonate solution and water; the mixture was then extracted with ethyl acetate. The aqueous layer was acidified with 1.0 M citric acid until the pH was ~ 4. The mixture was extracted three times with ethyl acetate. The combined organic layers were dried with magnesium sulfate and concentrated *in vacuo*. Compound 7 was also found in the first ethyl acetate extraction so it was also added to the crude product. Purification of acid 7 was performed by silica gel column chromatography (1 : 2 diethyl ether - pet. ether with 1% acetic acid) resulting in a 49% yield (21.2 mg, 0.0670 mmol) of a clear colourless oil.  $^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) 7.41 (d, 1.3H,  $J = 7.6$  Hz, H -17 and H -13), 7.37 (d, 1.3H,  $J = 7.6$  Hz, H -17 and H -13), 7.28 (t, 2H,  $J = 7.6$  Hz, H-16 and H-14), 7.18 (t, 1H,  $J$

= 7.2 Hz, H-15), 5.17 (bs, 0.66H, H-2), 4.93 (bs, 0.33H, H-2), 2.75 (s, 1.05H, H-6), 2.62 (s, 1.95H, H-6), 1.55 (s, 3H, H-5 or H-4), 1.49 - 1.39 (m, 12H, H-5 or H-4 and H-11, H-10 and H-9); Mass spectrum (EI) 307 (0.1, M<sup>+</sup>), 234 (3, [M-O*t*-Bu]<sup>+</sup>), 119 (100, [C<sub>9</sub>H<sub>11</sub>]<sup>+</sup>), 57 (78, [C<sub>4</sub>H<sub>9</sub>]<sup>+</sup>); Exact mass calc'd for C<sub>17</sub>H<sub>25</sub>NO<sub>4</sub>: 307.1783. Found (EI): 307.1793.

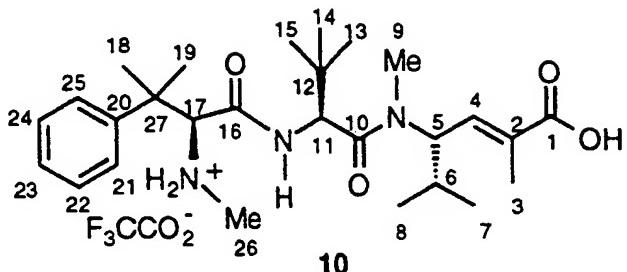
### Preparation of Compound 9



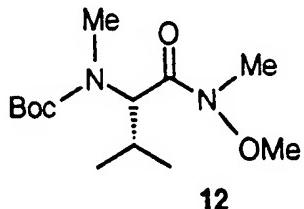
The *N*-Boc-amino ester **8** (71.6 mg, 0.174 mmol) was dissolved in 1 mL CH<sub>2</sub>Cl<sub>2</sub> and 1 mL of TFA was added. The reaction mixture was stirred at room temperature for 0.5 h. Removal of the solvent *in vacuo*, followed by repeated rinsing of the remaining material with CH<sub>2</sub>Cl<sub>2</sub> (3 x 5 mL) and evaporation of the residual solvent afforded the TFA salt of the amino acid ester **8**. In a separate flask, to a solution (or suspension) of the *N*-Boc protected amino acid **7** (51.5 mg, 0.167 mmol) in 0.5 mL CH<sub>2</sub>Cl<sub>2</sub>, was added DIEA (0.0875 mL, 0.503 mmol), DMAP (0.031 mg, 0.10 mmol) and PyBroP (0.0781 mg, 0.167 mmol). The solution was stirred for a few minutes and then a solution of the TFA salt of **8** was added in 1 mL of CH<sub>2</sub>Cl<sub>2</sub> *via* cannula addition. The reaction mixture was stirred at room temperature for 18 h. To the mixture was added water, CH<sub>2</sub>Cl<sub>2</sub> and ten drops of 10% aqueous HCl. The resulting biphasic solution was extracted with CH<sub>2</sub>Cl<sub>2</sub> (three times with 20 mL). The organic layer was extracted with saturated aqueous sodium hydrogen carbonate (10 mL), dried with magnesium sulfate and the solvent was removed *in vacuo*. The product was purified by flash chromatography (silica gel, 1 : 1 diethyl ether - pet. ether) affording the protected tripeptide **9** as a clear colourless oil in 27% yield (0.0272 g, 0.0454 mmol). <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) 7.84 (bd, 1H, J = 9.5 Hz, N-H), 7.4 - 7.30 (m, 5H, H-28, H-27, H-25, H-24), 7.21 (bt, 1H, J = 7.2 Hz, H-26), 6.63 (bd, 1H, J = 9.6 Hz, H-6), 5.08 (t, 1H, J = 9.6 Hz, H-7), 4.83 (d, 1H, J = 9.5 Hz, H-13), 4.17 (q, 2H, J = 7.1 Hz, H-2), 3.02 (s, 3H, H-11), 2.15 (s, 0.66H, H-29), 2.02 (s, 2.37H, H-29), 1.94 - 1.81 (m, 1H, H-8), 1.88 (s, 3H, H-5), 1.39 - 1.38 (m, 9H, H-34, H-33 and H-32), 1.28 (t, 3H, J = 7.1 Hz, H-1), 0.98 (s, 9H, H-

17, H-16 and H-15), 0.83, 0.77 (d, 3H,  $J$  = 6.6 Hz, H-10 and H-9); PyBroP is described in E. Frérot et al. (1991) Tetrahedron 47:259.

SPA110 - trifluoroacetate salt (10)

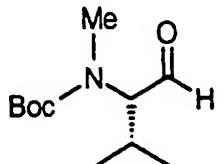


To a solution of the ethyl ester **9** (23.0 mg, 0.0382 mmol) in 1.1 mL MeOH was added 0.30 mL water and 0.31 mL of a 1.0 M aqueous solution of lithium hydroxide (0.31 mmol). The reaction mixture was stirred at room temperature overnight (~20 h) whereupon it was acidified by dropwise addition of 1.0 M citric acid and then extracted three times with ethyl acetate. The combined organic extracts were dried with magnesium sulfate and concentrated *in vacuo*. Under an argon atmosphere, the crude oil was dissolved in 1 mL CH<sub>2</sub>Cl<sub>2</sub> and the solution was treated with TFA (1 mL) and then was stirred at room temperature for 0.5 h. Removal of the excess solvents *in vacuo*, followed by rinsing of the remaining material three times with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and evaporation of the residual solvent, produced the TFA salt. HPLC purification of the crude product using a Magnum reverse phase C-18 column (H<sub>2</sub>O(45) : MeOH(55) with 0.05% TFA) afforded the tripeptide **10** as a white powder. <sup>1</sup>H-NMR (400 MHz, CD<sub>3</sub>OD) 7.53 (d, 2H,  $J$  = 7.6, H-25 and H-21), 7.44 (t, 2H,  $J$  = 7.6 Hz, H-24 and H-22), 7.34 (t, 1H,  $J$  = 7.6 Hz, H-23), 6.76 (d, 1H,  $J$  = 9.1 Hz, H-4), 5.04 (t, 1H,  $J$  = 10.1 Hz, H-5), 4.91, 4.34 (s, 1H, H-17 and H-11), 3.13 (s, 3H, H-9), 2.49 (H-26), 2.08 - 1.99 (m, 1H, H-6), 1.90 (s, 3H, H-3), 1.46, 1.37 (s, 3H, H-19 and H-18), 1.05 (s, 9H, H-15, H-14 and H-13), 0.89 (d, 3H,  $J$  = 6.1 Hz, H-8 or H-7), 0.88 (d, 3H,  $J$  = 6.5 Hz, H-8 or H-7); Mass spectrum (EI) 474 (0.1, [M-CF<sub>3</sub>CO<sub>2</sub><sup>-</sup>]<sup>+</sup>), 458 (0.1, [M-16-CF<sub>3</sub>CO<sub>2</sub><sup>-</sup>]<sup>+</sup>), 382 (2), 162 (62), 69 (74), 45(100).

*N*<sup>α</sup>-Boc-*N*<sup>α</sup>-methyl-L-valine *N*-methoxy-*N*-methylamide (12)

12

To a cold (0°C) solution of *N*-Boc-*N*-methylvaline (11) (5.0 g, 21.6 mmol), *N,O*-dimethylhydroxylamine hydrochloride (2.8 g, 28 mmol), and PyBOP® (11.2 g, 22 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (22 mL) was added DIEA (8.4 mL, 75 mmol). After 1 min., the reaction mixture was warmed to room temperature and stirring was continued for 1 h. If the pH value of the mixture was less than 7, the mixture could be treated with a few drops DIEA to allow the reaction to go to completion. The mixture was poured into 200 mL of diethyl ether and the resultant mixture was washed successively with 3 N hydrochloric acid (3 x 30 mL), saturated aqueous sodium hydrogen carbonate solution (3 x 30 mL), and saturated aqueous sodium chloride (3 x 30 mL). The organic layer was dried with magnesium sulfate and the solvent was evaporated, followed by chromatography of the crude product (silica gel, 1 : 3 diethyl ether - pet. ether), afforded 12 (4.46 g, 75% yield) as a colourless oil. <sup>1</sup>H-NMR (200 MHz, CDCl<sub>3</sub>): 0.84 (d, *J* = 6.6 Hz, 4H, (CH<sub>3</sub>)<sub>2</sub>), 0.85 (d, *J* = 6.6 Hz, 2H, (CH<sub>3</sub>)<sub>2</sub>), 1.41 (s, 6H, Boc-(CH<sub>3</sub>)<sub>3</sub>), 1.44 (s, 3H, Boc-(CH<sub>3</sub>)<sub>3</sub>), 2.15 - 2.30 (m, 1H, CH), 2.75 (s, 1H, NCH<sub>3</sub>), 2.78 (s, 2H, NCH<sub>3</sub>), 3.10 (bs, 3H, NCH<sub>3</sub>), 3.64 (s, 1H, OCH<sub>3</sub>), 3.68 (s, 2H, OCH<sub>3</sub>), 4.66 (d, *J* = 10 Hz, 0.4H, CH), 4.95 (d, *J* = 10 Hz, 0.6H, CH); Exact mass calc'd for C<sub>13</sub>H<sub>27</sub>N<sub>2</sub>O<sub>4</sub> (M+H)<sup>+</sup>: 275.19708. Found (DCI): 275.19710. Optical rotation obtained was [α]<sub>D</sub><sup>25</sup> +128.3 (c 2.9, CHCl<sub>3</sub>).

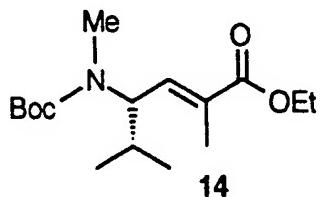
*N*-Boc-*N*-methyl-L-valinal (13)

13

Lithium aluminum hydride (875 mg, 23 mmol) was added to a solution of *N*<sup>α</sup>-Boc-*N*<sup>α</sup>-methyl-L-valine *N*-methoxy-*N*-methylamide (12) (2.0 g, 7.7 mmol) in dry THF (8 mL) and the reaction mixture was stirred for 20 min. The mixture was poured into a stirring solution of potassium hydrogen sulfate (3.14 g, 23 mmol) in water (100 mL). Diethyl ether (75 mL) was

added, the layers separated and the aqueous layer extracted with diethyl ether (3 x 50 mL). The organic layers were combined, and washed sequentially with 3 N hydrochloric acid (3 x 30 mL), saturated aqueous sodium hydrogen carbonate (3 x 30 mL), and saturated aqueous sodium chloride (3 x 30 mL). The organic layer was dried with magnesium sulfate and the solvent was evaporated to yield the crude aldehyde 13 (1.52 g, 92% yield). Aldehyde 13 was used without further purification. Note: 13 can be stored under argon for ~ 2 weeks, but when stored in organic solvents at room temperature, undergoes slow decomposition.  $^1\text{H-NMR}$  (200 MHz,  $\text{CDCl}_3$ ) 0.73 (d,  $J = 6.9$  Hz, 3H,  $\text{CH}_3$ ), 0.91 (d,  $J = 6.9$  Hz, 3H,  $\text{CH}_3$ ), 1.27 (s, 9H,  $\text{Boc-(CH}_3)_3$ ), 2.02 - 2.15 (m, 1H,  $\text{CH}$ ), 2.63 (s, 2H,  $\text{NCH}_3$ ), 2.72 (s, 1H,  $\text{NCH}_3$ ), 3.44 (d,  $J = 9.5$  Hz, 0.5H,  $\text{CH}$ ), 3.86 (d,  $J = 9$  Hz, 0.5H,  $\text{CH}$ ), 9.45 (s, 1H,  $\text{CH}$ ); Exact mass calc'd for  $\text{C}_{11}\text{H}_{22}\text{NO}_3$  ( $\text{M}+\text{H}$ ) $^+$ : 216.15997; Found (DCI): 216.15996; Optical rotation obtained was  $[\alpha]_D^{25} -104.2$  (c 5.5,  $\text{CHCl}_3$ ).

Ethyl (2E,4S)-N-Boc-N-methyl-4-amino-2,5-dimethylhex-2-enoate (14)



To a solution of aldehyde 13 (1.75 g, 8.7 mmol) in dry  $\text{CH}_2\text{Cl}_2$  (9.0 mL) under an argon atmosphere at room temperature was added (carbethoxyethylidene)triphenylphosphorane (4.19 g, 11.3 mmol) and stirring was continued for a 4 h. The reaction mixture was diluted with water (100 mL) and extracted with diethyl ether (3 x 100 mL). The combined organic extracts were washed with saturated aqueous sodium chloride (100 mL), dried with magnesium sulfate and concentrated *in vacuo*. The crude oil was purified by flash chromatography (silica gel, 2 : 23 diethyl ether - pet. ether) to afford the required *E*-2-alkenoate 14 as a colourless oil (2.13 g, 82% yield).  $^1\text{H-NMR}$  (200 MHz,  $\text{CDCl}_3$ ) 0.74 (d,  $J = 6$  Hz, 3H,  $\text{CH}_3$ ), 0.79 (d,  $J = 6$  Hz, 3H,  $\text{CH}_3$ ), 1.17 (t,  $J = 7$  Hz, 3H,  $\text{CH}_3$ ), 1.34 (s, 9H,  $\text{Boc-(CH}_3)_3$ ), 1.72 (m, 1H,  $\text{CH}$ ), 1.78 (s, 3H,  $\text{CH}_3$ ), 2.60 (bs, 3H,  $\text{NCH}_3$ ), 4.08 (q,  $J = 7$  Hz, 2H,  $\text{CH}_2$ ), 4.15 - 4.20 (m, 0.5H,  $\text{CH}$ ), 4.21 - 4.32 (m, 0.5H,  $\text{CH}$ ), 6.54 (d,  $J = 8$  Hz, 1H,  $\text{CH}$ ); Exact mass calc'd for  $\text{C}_{16}\text{H}_{30}\text{NO}_4$  ( $\text{M}+\text{H}$ ) $^+$ : 300.21750; Found (DCI): 300.21754. Optical rotation obtained was  $[\alpha]_D^{25} +61.1$  (c 9.1,  $\text{CHCl}_3$ ).

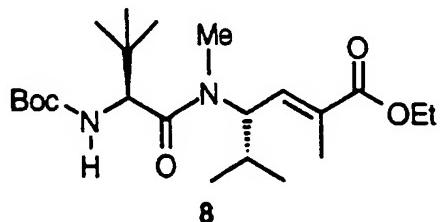
General procedure 1: Trifluoroacetic acid mediated cleavage of N-Boc groups

N-Boc-amino acid ester (1.0 equiv.) was treated with TFA /CH<sub>2</sub>Cl<sub>2</sub> (0.1 mmol / 1 mL) at room temperature for 0.5 h. Removal of the solvent *in vacuo*, followed by repeated rinsing of the residual material with CH<sub>2</sub>Cl<sub>2</sub> (3 x 5 mL) and evaporation of the remaining traces of solvent afforded the TFA salt of the amino acid ester in quantitative yield. TFA salts were used without further purification.

General procedure 2: Trimethylacetyl chloride mediated peptide coupling

To a cold (-78 C) stirred solution of acid (1.1 equiv.) in dry THF (1 mL /mmol) under an argon atmosphere was added DIEA (1.5 equiv.) and trimethylacetyl chloride (1.2 equiv.). The resulting mixture was warmed to 0°C for 1 h and then re-cooled to -78 C. DIEA (2.2 equiv.) was added *via* cannula to the reaction flask followed by the addition *via* cannula of the TFA salt of the amino acid ester (1.0 equiv., prepared by general procedure 1) in dry THF (0.5 mL/mmol) at -78 C. Stirring was continued for 1 h and water (40 mL) was added. The mixture was allowed to warm to room temperature, and extracted with diethyl ether (3 x 50 mL). The combined organic extracts were washed with saturated aqueous sodium chloride (50 mL), dried over magnesium sulfate, and concentrated *in vacuo*. The crude oil was purified by flash chromatography (silica gel, diethyl ether - pet. ether) to afford the desired dipeptide as a colourless oil.

Dipeptide 8



Following general procedure 2, dipeptide 8 was prepared with the following quantities of reagents and solvents: *N*-Boc-*tert*-leucine (15), 156 mg (0.52 mmol); trimethylacetyl chloride, 64 mL (0.52 mmol); DIEA, 99 mL (0.57 mmol); *N*-Boc-MHVV-OEt (14), 110 mg (0.47 mmol); DIEA, 198 mL (1.14 mmol); THF, 7 mL. Purification of the crude product by flash chromatography (silica gel, 1 : 5 diethyl ether - pet. ether) afforded 121 mg of 8 (62% yield). <sup>1</sup>H-NMR (200 MHz, CDCl<sub>3</sub>) 0.76 (d, J = 6 Hz, 3H, CH<sub>3</sub>), 0.80 (d, J = 6 Hz, 3H, CH<sub>3</sub>), 0.88 (s,

9H, (CH<sub>3</sub>)<sub>3</sub>), 1.22 (t, J = 7 Hz, 3H, CH<sub>3</sub>), 1.33 (s, 9H, Boc-(CH<sub>3</sub>)<sub>3</sub>), 1.79 - 1.89 (m, 1H, CH), 1.83 (s, 3H, CH<sub>3</sub>), 2.91 (s, 3H, NCH<sub>3</sub>), 4.12 (q, J = 7 Hz, 2H, CH<sub>2</sub>), 4.35 (d, J = 10 Hz, 1H, CH), 5.03 (t, J = 10 Hz, 1H, CH), 5.14 (d, J = 10 Hz, 1H, NH), 6.57 (d, J = 8 Hz, 1H, CH); Exact mass calc'd for C<sub>22</sub>H<sub>41</sub>N<sub>2</sub>O<sub>5</sub> (M+H)<sup>+</sup>: 413.30154; Found (DCI): 413.30119. Optical rotation obtained was [α]<sub>D</sub><sup>25</sup> -76.9 (c 2.43, CHCl<sub>3</sub>).

- 26 -

Assay for Cytotoxicity

Cytotoxicity of SPA-110 compared to hemiasterlin as  
against p53+ and p53- variants of human breast cancer MCF-7  
5 cells and A549 tumor cells was determined according to the  
methods described in J. Immunol. Methods 65:55-63 (1983).  
Results shown in Figures 5A and 5B show that SPA-110 is  
more cytotoxic in some instances than the naturally  
occurring compound.

10

Assay for Antimitotic Activity

Antimitotic activity is detected by enzyme-linked  
immunosorbent assay using a mitosis-specific antibody, TG-3  
15 (from Albert Einstein College of Yeshiva University, Bronx,  
N.Y.; and see: PCT application published July 4, 1996  
under WO96/20218).

MCF-7 mp53- cells (expressing a dominant-negative p53  
20 mutation as described in S. Fan, et al. (1995) Cancer  
Research 55:1649-1654) were cultured as monolayers in DMEM  
supplemented with 10% fetal bovine serum, 2 mM L-glutamine,  
50 units /ml penicillin, 50 µg/ml streptomycin, 1 mM sodium  
pyruvate, MEM non-essential amino acids, 1 µg/ml bovine  
25 insulin, 1 µg/ml hydrocortisone, 1 ng/ml human epidermal  
growth factor, and 1 ng/ml β-estradiol at 37°C in humidified  
5% CO<sub>2</sub>. The cells were seeded at 10,000 cells per well of  
96-well polystyrene tissue culture plates (Falcon) in a  
volume of 200 µl cell culture medium. The cells were  
30 allowed to grow for 24 hours and compounds were added at  
about 1 µg/ml or 10 µg/ml (from 1000-fold stocks in  
dimethylsulfoxide) and the cells were incubated for 20  
hours. Nocodazole (Sigma) served as a positive control.  
After treatment with the agent to be tested, the cell  
35 culture medium was removed completely and the 96-well  
tissue culture plates were frozen at -70°C for up to 2  
hours. The frozen cells were thawed by addition of 100 µl

- 27 -

of ice-cold lysis buffer (0.5 mM phenylmethylsulfonylfluoride, 1 mM ethylene glycol-bis(β-aminoethyl ether) N,N,N,N'-tetraacetic acid, pH 7.4,) and lysed by pipeting up-and-down 10 times. The 5 cell lysates were transferred to 96-well PolySorp ELISA plates (Nunc) and dried completely by blowing warm air at about 37°C with a hair drier positioned about 3 feet above the plates. Protein binding sites were blocked by adding 200 µl per well of 10 mM Tris HCl pH 7.4, 150 mM NaCl, 10 0.1 mM PMSF, 3% (w/v) dried non-fat milk (Carnation) for 1 hour at room temperature. This was removed and replaced with 100 µl of the same solution containing 0.1-0.15 µg/ml TG-3 mitosis-specific monoclonal antibody and horseradish peroxidase-labelled goat anti-mouse IgM (1021-05, Southern 15 Biotechnology Associates) at a dilution of 1/500. After overnight incubation at 4°C, the antibody solution was removed and the wells were rinsed 3 times with 200 µl rinse buffer (10 mM Tris HCl pH 7.4, 0.02% Tween 20). 100 µl of 20 120 mM Na<sub>2</sub>HPO<sub>4</sub>, 100 mM citric acid, pH 4.0 containing 0.5 mg/ml 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) and 0.01% hydrogen peroxide was added for 1 hour at room temperature and the plates were read at 405 nm using a BioTek plate reader.

25 Results comparing antimitotic activity of hemiasterlin to SPA-110 are shown in Figure 6. SPA-110 exhibited considerably greater antimitotic activity than the naturally occurring compound.

30 In Vivo Activity of SPA-110

The compound SPA-110 was evaluated *in vivo* using standard pharmacological test procedures which measure its ability to inhibit the growth of human tumor xenografts. 35 The human colon carcinoma LOVO (American Type Culture Collection, Rockville, Maryland #CCL-229) was grown in tissue culture in RPMI supplemented with 10% FBS. Athymic

nu/nu female mice (Charles River, Wilmington, MA) were injected sub-cutaneously in the flank area with  $7.0 \times 10^6$  LOVO cells. When tumors attained a mass of between 80 and 120 mg, the mice were randomized into treatment groups (day zero). Animals were treated intravenously once a day on days 1, 5, and 9 post staging (day zero) with 1 mg/kg/dose of SPA-110 prepared in 2.5% ethanol in saline or with saline as the vehicle control. Some animals were treated intraperitoneally once a day on days 1, 5 and 9 post staging with 1 mg/kg/dose Vincristine as a positive control. Tumor mass was determined every 7 days [(length x width<sup>2</sup>)/2] for 28 days post staging. RTG or relative tumor growth (Mean tumor mass on days 7, 14, 21 and 28 divided by the mean tumor mass on day zero) was determined for each treatment group. % T/C was calculated as RTC (treated group) / RTC (vehicle control group) x 100. Statistical analysis (Student-t-test) of log relative tumor growth was used to compare treated verses control group in each experiment. A p-value ( $p \leq 0.05$ ), which indicates a statistically significant reduction in relative tumor growth, was obtained in each case. 5 of 5 animals treated at day 28 with SPA-110 survived. 9 of 10 animals treated at day 28 with vincristine survived. The results are shown in the following table.

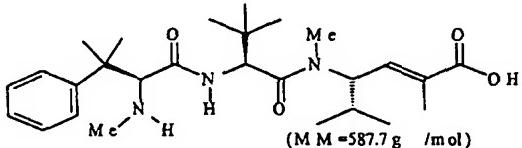
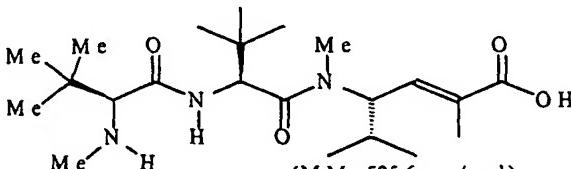
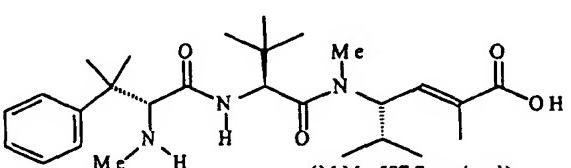
25

Treatment	% T/C day 7	% T/C day 14	% T/C day 21	% T/C day 28
Vincristine	34	37	44	47
SPA-110 1 mg/kg	16	18	30	47

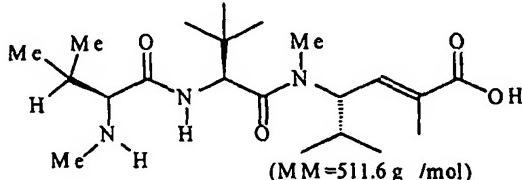
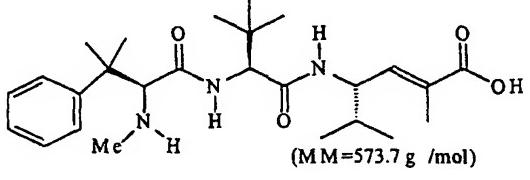
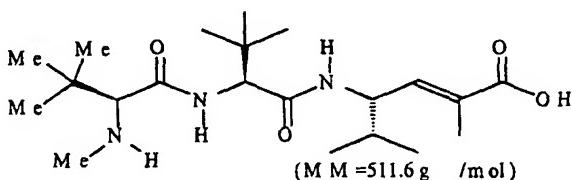
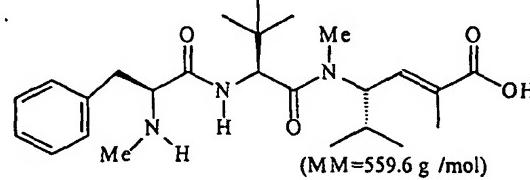
- 29 -

Relative Activity of Compounds of this Invention

Various analogs of SPA-110 have been synthesized and characterized for their cytotoxic and anti-mitotic activities. The high degree of correlation between cytotoxicity and anti-mitotic capacity indicates that the cytotoxicity of the compounds of this invention is due to the compounds' anti-mitotic activity. The following structures are analogs falling within the scope of this invention depicted in approximately descending order of cytotoxic/anti-mitotic activity.

Compound Name	Compound structure (TFA salt) Me = CH <sub>3</sub>
SPA 110	 $(M.M. = 587.7 \text{ g/mol})$
SPA115	 $(M.M. = 525.6 \text{ g/mol})$
SPA123	 $(M.M. = 587.7 \text{ g/mol})$

- 30 -

5	<b>SPA116</b>  (MM=511.6 g /mol)
10	<b>SPA121</b>  (MM=573.7 g /mol)
15	<b>SPA122</b>  (MM=511.6 g /mol)
20	<b>SPA114</b>  (MM=559.6 g /mol)

25

As will be apparent to those skilled in the art in the  
30 light of the foregoing disclosure, many alterations and  
modifications are possible in the practice of this  
invention without departing from the spirit or scope  
thereof. Accordingly, the scope of the invention is to be  
construed in accordance with the substance defined by the  
35 claims herein, which substance includes obvious chemical  
equivalents of the compounds and methods set out in the  
claims.

- 31 -

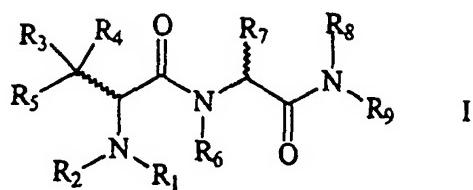
WE CLAIM:

1. A compound or pharmaceutically acceptable salt thereof, having the formula

5

10

15



20

wherein,

25      R<sub>1</sub> and R<sub>2</sub> are independently selected from the group consisting of: H, R, and ArR-, and where at least one of R<sub>1</sub> and R<sub>2</sub> is R and neither are ArR-, R<sub>1</sub> and R<sub>2</sub> together may optionally be a three to seven member ring;

30      R<sub>3</sub> and R<sub>4</sub> are independently selected from the group consisting of: H, R, ArR-, and where at least one of R<sub>3</sub> and R<sub>4</sub> is R and neither are ArR- or Ar, R<sub>3</sub> and R<sub>4</sub> together may optionally be a three to seven member ring;

R<sub>5</sub> is selected from the group consisting of: H, R, ArR-, and Ar;

35

R<sub>6</sub> is selected from the group consisting of: H, R, and ArR-;

- 32 -

R<sub>7</sub> and R<sub>8</sub> are independently selected from the group consisting of: H, R, and ArR-; and

R<sub>9</sub> is: Z-C<sup>O</sup>-Y-;

5

and wherein,

R is defined as a saturated or unsaturated moiety having a linear, branched, or cyclic skeleton containing one to ten carbon atoms, zero to four nitrogen atoms, zero to four oxygen atoms, and zero to four sulfur atoms, and the carbon atoms are optionally substituted with: =O, =S, -OH, -OR<sub>10</sub>, -O<sub>2</sub>CR<sub>10</sub>, -SH, -SR<sub>10</sub>, -SO<sub>2</sub>CR<sub>10</sub>, -NH<sub>2</sub>, -NHR<sub>10</sub>, -N(R<sub>10</sub>)<sub>2</sub>, -NHCOR<sub>10</sub>, -NR<sub>10</sub>COR<sub>10</sub>, -I, Br, -Cl, -F, -CN, -CO<sub>2</sub>H, -CO<sub>2</sub>R<sub>10</sub>, -CHO, -COR<sub>10</sub>, -CONH<sub>2</sub>, -CONHR<sub>10</sub>, -CON(R<sub>10</sub>)<sub>2</sub>, -COSH, -COSR<sub>10</sub>, -NO<sub>2</sub>, -SO<sub>3</sub>H, -SOR<sub>10</sub>, -SO<sub>2</sub>R<sub>10</sub>, wherein R<sub>10</sub> is a linear, branched or cyclic, one to ten carbon saturated or unsaturated alkyl group;

20 X is defined as a moiety selected from the group consisting of: -OH, -OR, =O, =S, -O<sub>2</sub>CR, -SH, -SR, -SO<sub>2</sub>CR, -NH<sub>2</sub>, -NHR, -N(R)<sub>2</sub>, -NHCOR, -NRCOR, -I, -Br, -Cl, -F, -CN, -CO<sub>2</sub>H, -CO<sub>2</sub>R, -CHO, -COR, -CONH<sub>2</sub>, -CONHR, -CON(R)<sub>2</sub>, -COSH, -COSR, -NO<sub>2</sub>, -SO<sub>3</sub>H, -SOR, and -SO<sub>2</sub>R;

25

Ar is defined as an aromatic ring selected from the group consisting of: phenyl, naphthyl, anthracyl, phenanthryl, furyl, pyrrolyl, thiophenyl, benzofuryl, benzothiophenyl, quinolinyl, isoquinolinyl, imidazolyl, thiazolyl, oxazolyl, and pyridinyl, optionally substituted with R or X;

30 Y is defined as a moiety selected from the group consisting of: a linear, saturated or unsaturated, one to six carbon alkyl group, optionally substituted with R, ArR-, or X; and,

- 33 -

Z is defined as a moiety selected from the group consisting of: -OH, -OR; -SH; -SR; -NH<sub>2</sub>; -NHR; -N(R)<sub>2</sub>; -NHCH(R<sub>11</sub>)COOH; and -NRCH(R<sub>11</sub>)COOH, wherein R<sub>11</sub> is a moiety having the formula: R, or -(CH<sub>2</sub>)<sub>n</sub>NR<sub>12</sub>R<sub>13</sub>, wherein n=1-4 and R<sub>12</sub> and R<sub>13</sub> are independently selected from the group consisting of: H; R; and -C(NH)(NH<sub>2</sub>).

2. The compound of claim 1 wherein Ar is phenyl, naphthyl, anthracyl, or pyrrolyl.

10 3. The compound of claim 2 where R<sub>5</sub> is phenyl, naphthyl, anthracyl, or pyrrolyl.

15 4. The compound of claim 1, 2 or 3 wherein R<sub>3</sub> and R<sub>4</sub> are independently selected from the group consisting of: methyl, ethyl, n-propyl and n-butyl; or, R<sub>3</sub> and R<sub>4</sub> together are selected from the group consisting of: β-cyclopropyl, β-cyclobutyl, β-cyclopentyl and β-cyclohexyl.

20 5. The compound of any of claims 1-4 wherein R<sub>1</sub> and R<sub>2</sub> are independently selected from the group consisting of: H, methyl, ethyl, propyl, n-butyl, acetyl; or, R<sub>1</sub> and R<sub>2</sub> are joined and form a moiety selected from the group consisting of cyclopropyl, cyclobutyl, cyclopentyl, and cyclohexyl.

25 6. The compound of any of claims 1-4 wherein R<sub>1</sub> and R<sub>2</sub> are independently: H, CH<sub>3</sub> or acetyl.

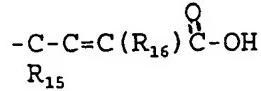
7. The compound of any of claims 1-4 wherein R<sub>1</sub> is H, and  
30 R<sub>2</sub> is -CH<sub>3</sub>.

8. The compound of any of claims 1-7 wherein Z is: OH, -OCH<sub>3</sub>, -NHCH(R<sub>11</sub>)COOH, or, -NCH<sub>3</sub>CH(R<sub>11</sub>)COOH, wherein R<sub>11</sub> is R, or -(CH<sub>2</sub>)<sub>n</sub>NHC(NH)(NH<sub>2</sub>).

- 34 -

9. The compound of any of claims 1-7 wherein Z is OH or -OR<sub>14</sub>, wherein R<sub>14</sub> is a linear or branched one to six carbon alkyl group.

5 10. The compound of any of claims 1-7 wherein R<sub>9</sub> has the formula:



10 wherein R<sub>15</sub> is selected from the group consisting of: methyl, ethyl, n-propyl, isopropyl, tert-butyl, iso-butyl, and sec-butyl; and R<sub>16</sub> is selected from the group consisting of: H, methyl, ethyl, propyl, iso-propyl, n-butyl, 15 iso-butyl and sec-butyl.

11. The compound of claim 10 wherein R<sub>15</sub> is isopropyl and R<sub>16</sub> is methyl.

20 12. The compound of any of claims 1-11 wherein R<sub>7</sub> is a three to six carbon, branched alkyl group.

13. The compound of any of claims 1-12 wherein R<sub>6</sub> and R<sub>8</sub> are independently: H, or CH<sub>3</sub>.

25 14. The compound of any of claims 1-11 wherein R<sub>6</sub> is H, R<sub>7</sub> is: -C(CH<sub>3</sub>)<sub>3</sub>, and R<sub>8</sub> is -CH<sub>3</sub>.

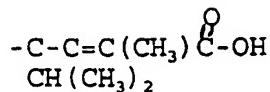
15. The compound of any of claims 1-14 wherein R<sub>3</sub> and R<sub>4</sub> 30 are each R.

16. The compound of any of claims 1-14 wherein R<sub>3</sub> and R<sub>4</sub> are each -CH<sub>3</sub>.

35 17. The compound of claim 16 wherein R<sub>5</sub> is phenyl.

- 35 -

18. The compound of claim 17 wherein R<sub>9</sub> has the formula:



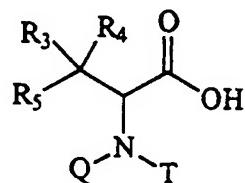
5

19. A method of preparing a compound as described in claim 1 comprising the step of:

(a) coupling an amino acid having the formula:

10

15

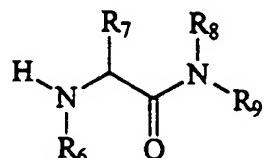


20 in which R<sub>3</sub> - R<sub>5</sub> are as defined in claim 1 and Q and T are selected from the group consisting of: R<sub>1</sub> and R<sub>2</sub> as defined in claim 1, and a protecting group;

with a dipeptide having the formula:

25

30



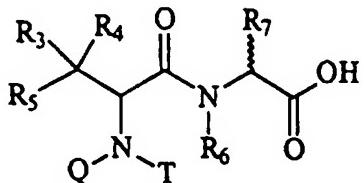
in which R<sub>6</sub> - R<sub>9</sub> are as defined in claim 1;

35 and, where Q or T is a protecting group, the additional step of replacing the protecting group with R<sub>1</sub> or R<sub>2</sub> to form compound I; or,

- 36 -

(b) coupling a dipeptide having the formula:

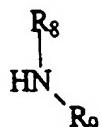
5



10 in which R<sub>3</sub> - R<sub>7</sub> are as defined in claim 1 and Q and T are as defined above;

with an amino acid having the formula:

15



20

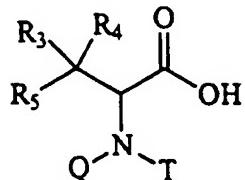
in which R<sub>8</sub> and R<sub>9</sub> are as defined in claim 1;

and, where Q or T is a protecting group, the additional  
25 step of replacing the protecting group with R<sub>1</sub> or R<sub>2</sub> to form compound I.

20. An amino acid suitable for use in the method of claim 19, having the formula:

30

35



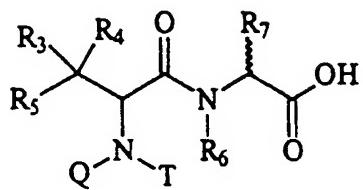
- 37 -

in which R<sub>3</sub> - R<sub>5</sub>, Q and T are as defined in claim 19.

21. A dipeptide suitable for use in the method of  
claim 19, having the formula:

5

10



15

in which R<sub>3</sub> - R<sub>7</sub>, Q and T are as defined in claim 19.

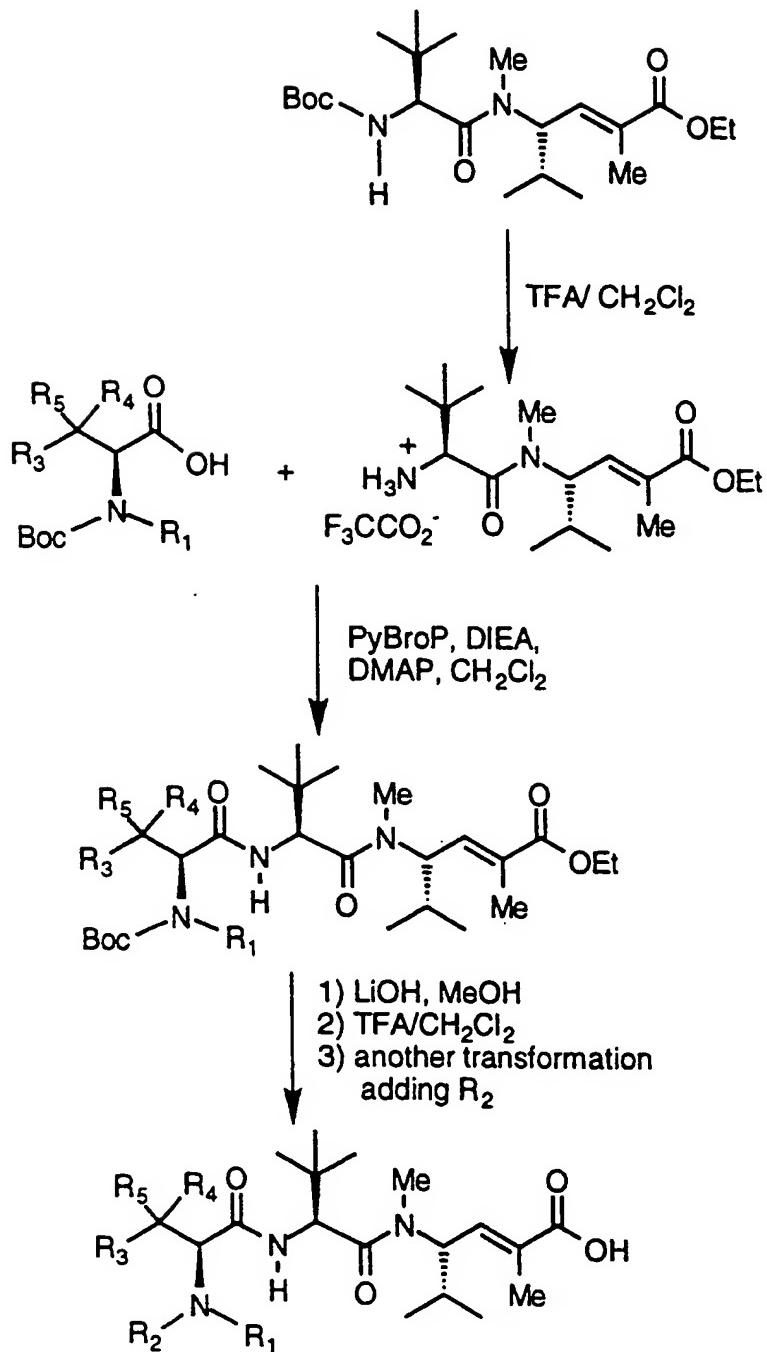


Figure 1

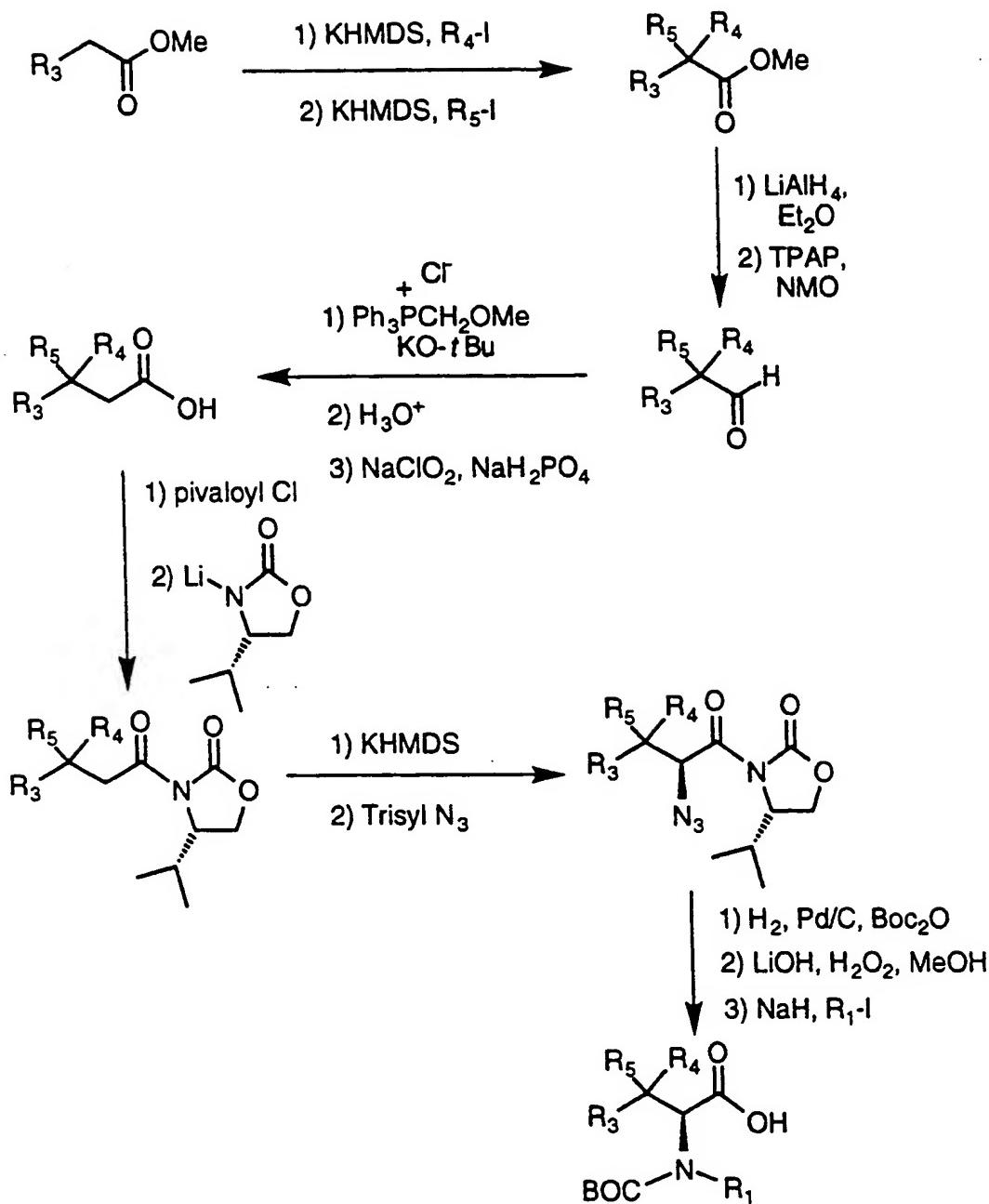


Figure 2

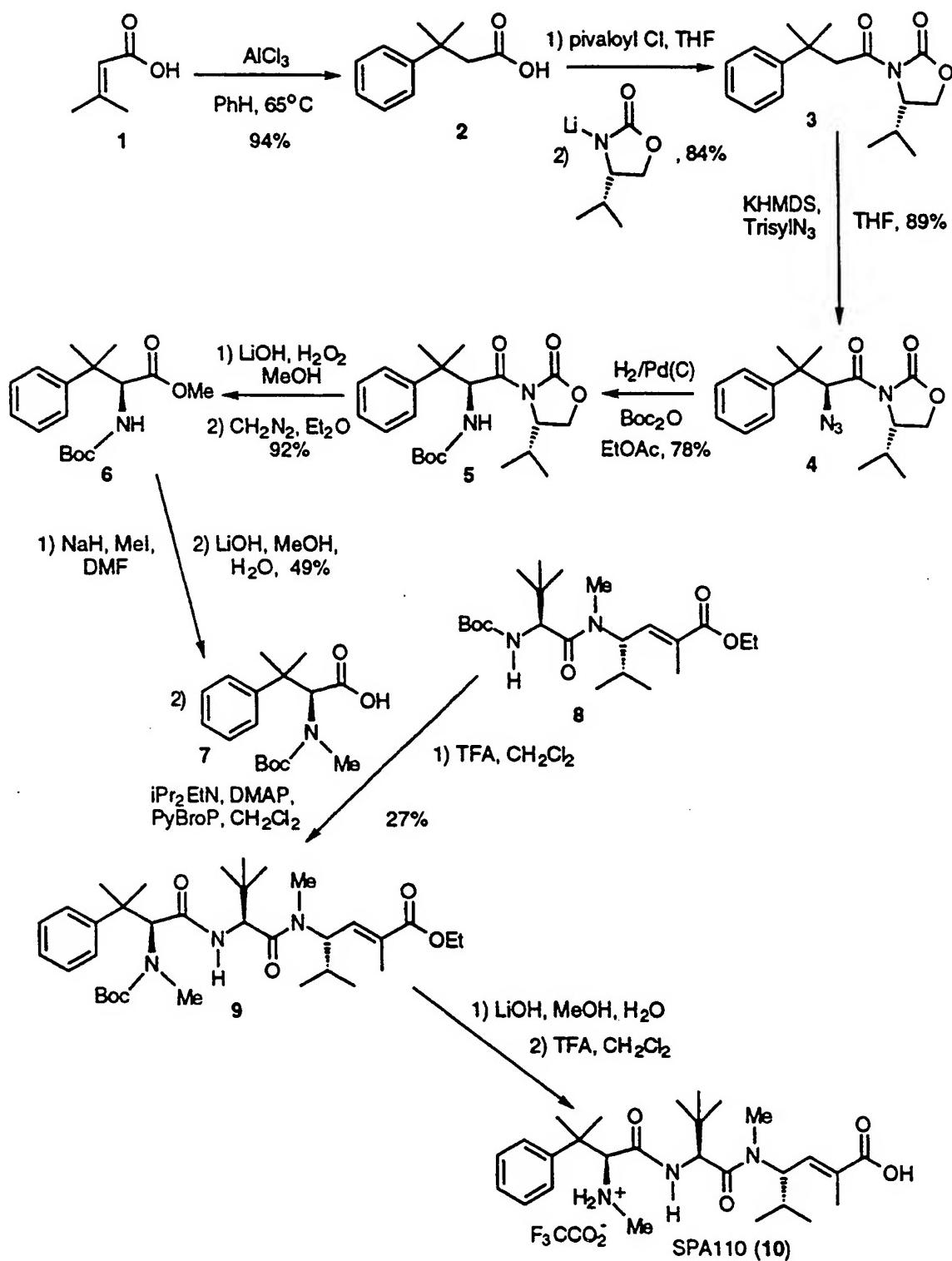


Figure 3

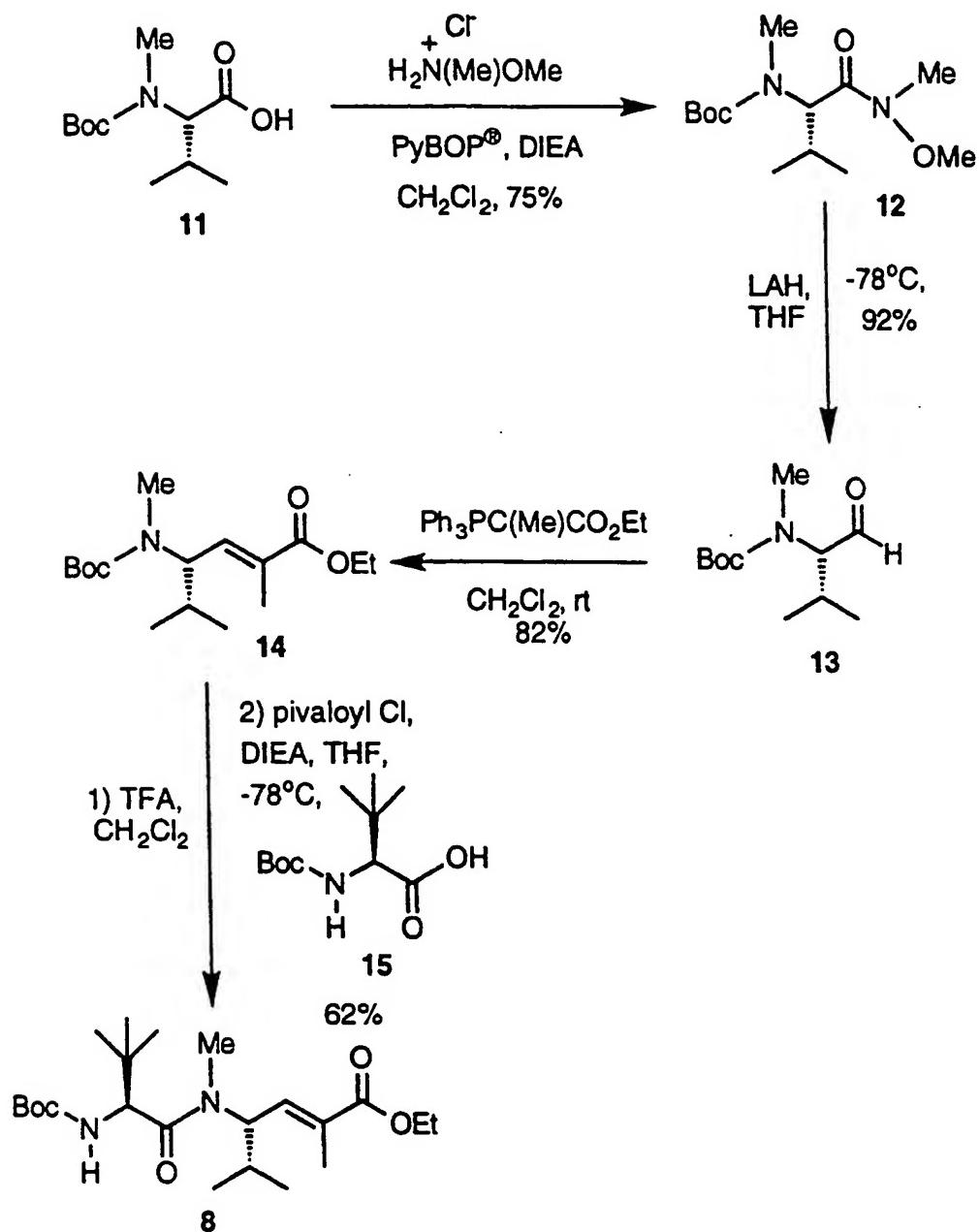


Figure 4

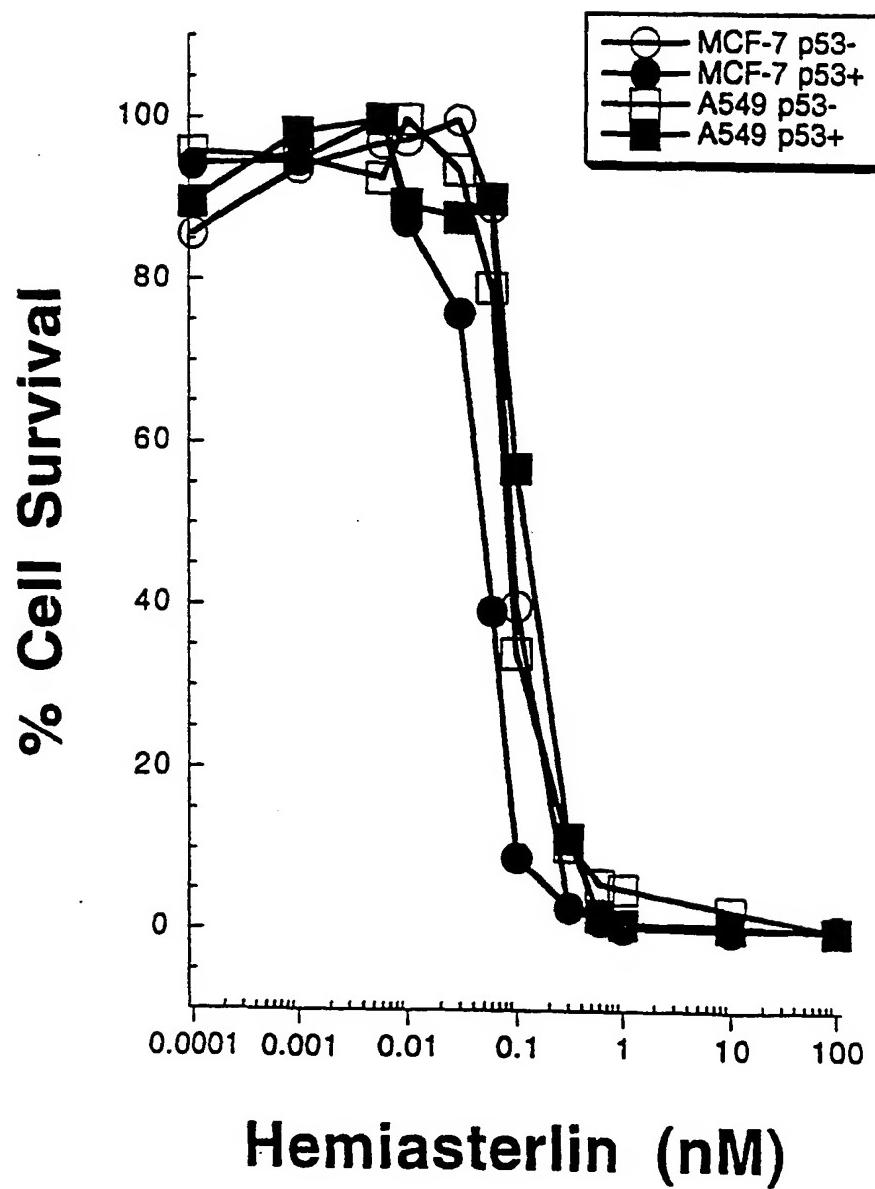


FIGURE 5A

6 / 7

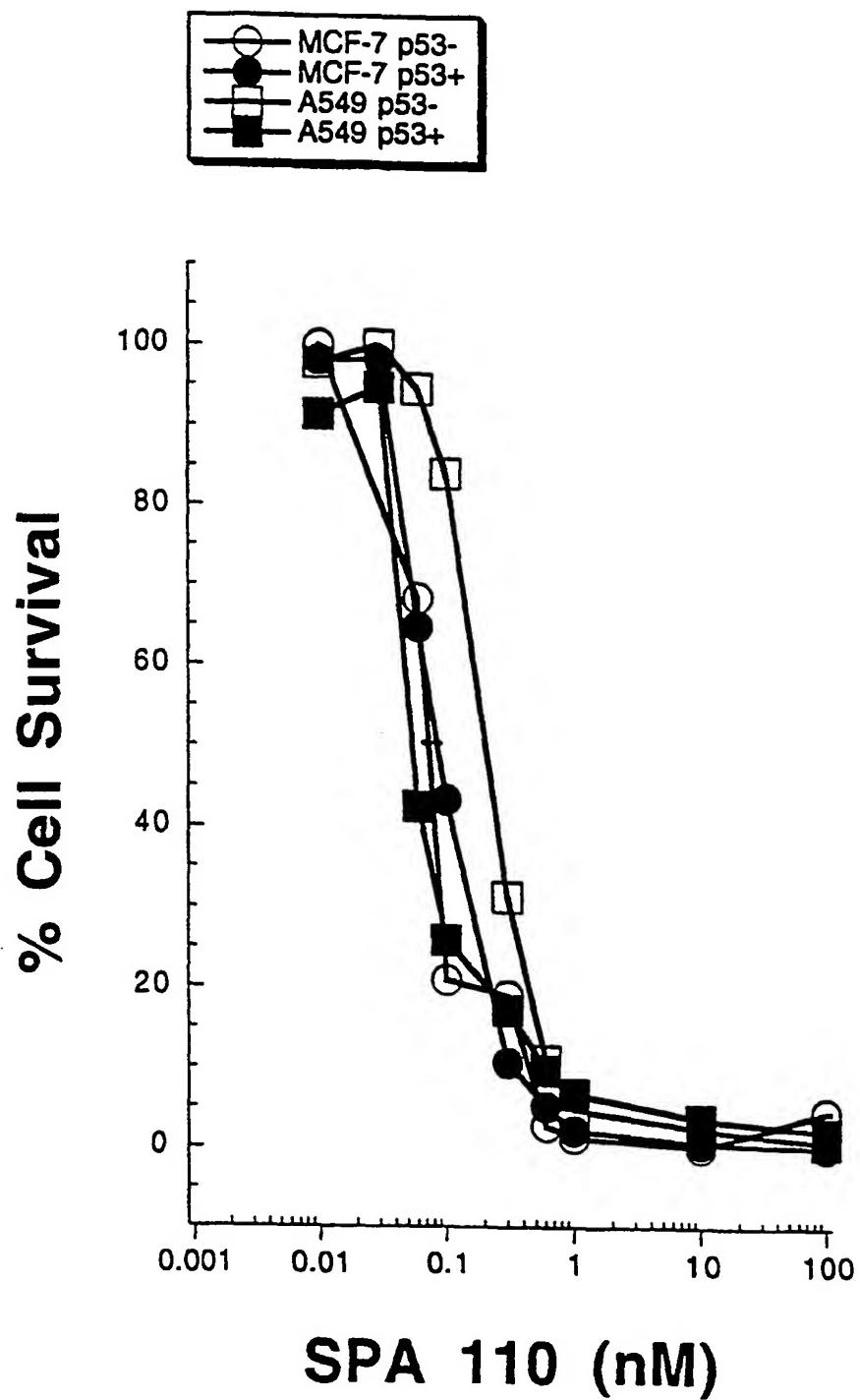


FIGURE 5B

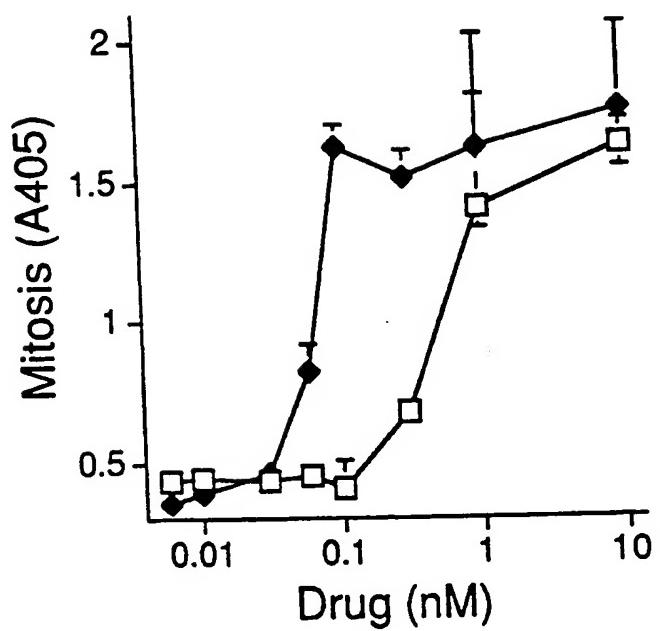


Figure 6

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> :  C07K 5/065, 5/062, A61K 38/05, C07K 5/02, 5/08		A3	(11) International Publication Number: <b>WO 99/32509</b>  (43) International Publication Date: <b>1 July 1999 (01.07.99)</b>
<p>(21) International Application Number: <b>PCT/CA98/01184</b></p> <p>(22) International Filing Date: <b>18 December 1998 (18.12.98)</b></p> <p>(30) Priority Data: 2,225,325                    19 December 1997 (19.12.97)      CA</p> <p>(71) Applicant (<i>for all designated States except US</i>): THE UNIVERSITY OF BRITISH COLUMBIA [CA/CA]; IRC Room 331, 2194 Health Sciences Mall, Vancouver, British Columbia V6T 1Z3 (CA).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (<i>for US only</i>): ANDERSEN, Raymond [CA/CA]; 4048 West 32nd Avenue, Vancouver, British Columbia V6S 1Z6 (CA). PIERS, Edward [CA/CA]; (CA). NIEMAN, James [CA/CA]; (CA). COLEMAN, John [CA/CA]; The University of British Columbia, Dept. of Chemistry, 6328 Memorial Road, Vancouver, British Columbia V6T 1Z3 (CA). ROBERGE, Michel [CA/CA]; 4228 West 10th Avenue, Vancouver, British Columbia V6R 2H4 (CA).</p> <p>(74) Agents: ROBINSON, J., Christopher et al.; Smart &amp; Biggar, Suite 2200, 650 West Georgia Street, Box 11560, Vancouver, British Columbia V6N 4N8 (CA).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p> <p>(88) Date of publication of the international search report: <b>7 October 1999 (07.10.99)</b></p>	
<p>(54) Title: <b>HEMIASTERLIN ANALOGS</b></p> <p>(57) Abstract</p> <p>This invention provides analogs of hemiasterlin, methods of synthesis of the analogs and use of the analogs as a cytotoxic and anti-mitotic agents.</p>			

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Larvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LJ	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

# INTERNATIONAL SEARCH REPORT

Int'l Application No  
PCT/CA 98/01184

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
IPC 6 C07K5/065 C07K5/062 A61K38/05 C07K5/02 C07K5/08		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC 6 C07K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 96 33211 A (UNIV BRITISH COLUMBIA ;UNIV ALBERTA (CA); APPLIEDENE LIMITED (GB);) 24 October 1996 (1996-10-24) cited in the application claim 1 ----	10,11, 14,18
Y	US 5 661 175 A (GRAVALOS DOLORES G . ET AL) 26 August 1997 (1997-08-26) claim 1 ----	10,11, 14,18
A	EP 0 150 227 A (FUJIIREBIO KK) 7 August 1985 (1985-08-07) ----	
A	US 4 048 305 A (MOLTENI LUIGI ET AL) 13 September 1977 (1977-09-13) ----	
<input type="checkbox"/> Further documents are listed in the continuation of box C.		<input checked="" type="checkbox"/> Patent family members are listed in annex.
<p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
Date of the actual completion of the international search	Date of mailing of the international search report	
4 August 1999	18.08.99	
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl. Fax: (+31-70) 340-3016	Authorized officer  Deffner, C-A	

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/CA 98/01184

### Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
  
3.  Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.  As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

#### Remark on Protest

- The additional search fees were accompanied by the applicant's protest.  
 No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1-7, 12, 13, 15-17, 19-21 (partially, only in as far as the claims depend on claims 10 and 14)

Present claims 1-9, 12, 13, 15-17 relate to an extremely large number of possible compounds. Support within the meaning of Article 6 PCT and disclosure within the meaning of Article 5 PCT is to be found, however, for only a very small proportion of the compounds claimed. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Present claim 1 embraces virtually Di-, Tri- and Tetrapeptides without any constant feature to which a pharmaceutical activity can be attributed. Consequently, the search has been carried out for those parts of the claims which appear to be supported and disclosed, namely those parts relating to the compounds.

Therefore only claims 10, 14, 18 and subject-matter in as far as it depends on these claims has been searched.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International Application No

PCT/CA 98/01184

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
WO 9633211	A	24-10-1996		AU 5341696 A		07-11-1996
				CA 2220021 A		24-10-1996
				EP 0839154 A		06-05-1998
US 5661175	A	26-08-1997		NONE		
EP 0150227	A	07-08-1985		NONE		
US 4048305	A	13-09-1977		IT 1049404 B		20-01-1981
				BE 860382 A		15-02-1978
				CA 1047485 A		30-01-1979
				DE 2615129 A		28-10-1976
				FR 2306709 A		05-11-1976
				GB 1525664 A		20-09-1978
				JP 1147558 C		26-05-1983
				JP 51136669 A		26-11-1976
				JP 57035866 B		31-07-1982